lettered as at present and known as Clavius A, Clavius B, and so on.

Then all the minor objects such as craterlets, ridges, hills, clefts, and spots would be simply numbered, and would be known as Clavius 1, Clavius 2, and so on. Reference to the catalogue would give the nature of the object so numbered. In this system it will be seen that we get rid of the necessity of distinguishing each class of objects by a separate class of symbol, and this by the use of a number only; and, further, this method would have the advantage of crowding the maps with fewer signs or figures than any other which seeks to differentiate one class of object from another by use of a different symbol.

It may be urged as an objection to this scheme that it presupposes the existence of an accurate map to be divided up.

Such does not exist; but for practical purposes Schmidt's map should be found sufficiently accurate for this purpose, and I would propose that the divisions be first found on photographs and then transferred to the map. The sections or divisions on the map could then be enlarged to any given scale, and have printed upon them a suitable réseau to be used for plotting accurately the position of objects from the coordinates given in Mr. Saunder's catalogue.

Report on Observations of Jupiter, 1904–5, *made at Trincomali, Ceylon.* By Major P. B. Molesworth.

Part I. Preliminary.

Arrangement of Report.—The present paper is in continuation of the observations for 1903–4, given in the *Monthly Notices*, vol. lxv. No. 7. The nomenclature and arrangement are the same in both cases.

Telescope.—The $12\frac{3}{4}$-inch Calver equatorial was again used; but for the greater part of the observations no driving clock was available, as the clock had been sent home to Messrs. Ottway of Ealing for a new one to be made. At the end of January the new driving clock (a very fine one) was installed and used till the end of the observations.

Scope of the Observations.—Work was begun in the early mornings on 1904 June 3, and carried on steadily till June 20. At this point I was suddenly laid up with a sharp attack of pleurisy and fever, which necessitated my taking leave home as soon as I was convalescent. No astronomical work was done in England owing to ill-health, but observations were resumed as soon as I returned to Trincomali on 1904 November 26. Regular work was carried on up to 1905 February 13, when a spell of very bad observing weather set in, and very few more visual

observations were obtained. I was then experimenting with photographs of *Jupiter* with very promising results, considering the improvised apparatus and the low altitude of the planet.

The number of nights on which C.M. transits were taken was fifty-seven, distributed as follows each month :—

		No. of Nights.			No. of Nights.
1904	June	12	1905	Jan.	16
	Nov.	3		Feb.	11
	Dec.	14		March	1

The planet was observed visually for a total period of 100 hours, an average of about $1^h\ 40^m$ per night. One thousand five hundred and seventy-seven C.M. transits were taken in an average of 15·8 per hour. Five sets of measures were made for latitude with the bifilar micrometer in 1905 February and March. Experimental photographs were taken on nine nights in February and March, several negatives being obtained each night; seven of the plates thus obtained were measured for latitude in an improvised measuring machine, and gave fair results which have been combined with those obtained with the micrometer (see page 104). One or two of the more prominent spots were also measured on the negatives for longitude.

Estimations of the colours and intensities of the belts were made on twenty-seven nights. Satellite phenomena were observed on twenty-seven nights, and careful satellite comparisons made on forty-five nights.

The long gap which broke the continuity of the observations from 1904 June to November has greatly detracted from their value. In a great many cases the identification of the markings was very uncertain, and I have therefore only worked out the rotation periods for those zones which I consider reliable.

The publication of results has again been greatly delayed by pressure of work.

Part II. Disc Observations.

I give a general description of the features noticed in the various zones and belts from south to north.

(*AA*) *S. Polar Region.*—Slightly striated, generally of a faint brownish-yellow tinge, the N. edge being slightly darker than the rest. The general tint is a colder grey than that of the N. Polar Region.

(*A*) *S.S. Zone.*—The dullest of all the zones, unusually dull this year; generally slightly shaded and barely visible. Very few brighter spots were noticed in it, and those seen were of a very transient nature.

(*B*) *S. Temperate Belt.*—Still rather faint, colourless grey. Owing to uncertainties of identification I have not worked out the periods of the markings in it, but they appear to have practically the same motion as in previous years.

(*C*) *S. Temperate Zone.*—Shows very little change since the last apparition, but its general tone seems to be rather brighter. The mean period deduced from eleven spots this year is $9^h\ 55^m\ 20^s{\cdot}23$, showing a slight retardation compared with last year. Denning's two White Spots (*Observatory*, 1904 September, page 345) were repeatedly observed, and show very regular periods of $9^h\ 55^m\ 20^s{\cdot}08$ and $9^h\ 55^m\ 20^s{\cdot}39$ respectively.

(*D*) *S. Tropical Belt.*—Very distinct, dark, and knotted, but rarely seen double in 1904–5. The general tint is a decided slate-grey with sometimes a cast of blue. I have worked out the rotation periods of the spots in it, but in some cases the identification is rather doubtful. The mean period for most of the belt was $9^h\ 55^m\ 20^s{\cdot}63$, but two fairly well-marked spots in $\lambda^\circ = 60^\circ$ and 72° respectively appeared to have an abnormally slow period of $9^h\ 55^m\ 27^s{\cdot}8$. Possibly my identification is at fault.

The Red Spot.—The appearance of this feature is practically unchanged, and my description in 1903–4 still applies. The bay is now quite shallow and symmetrical, and its breadth possibly decreased slightly during the apparition. The dark curved wisp from the following shoulder to the S. Tropical Belt was almost invariably seen, while that from the preceding shoulder was absent except during the passage of the dark area. The following end of the Red Spot itself is still the darkest, but the ringed appearance of the spot was not noticed. The mean period for the year was $9^h\ 55^m\ 40^s{\cdot}00$.

Great S. Tropical Dark Area.—This is the subject of a separate note in Part IV. It was just coming into conjunction with the Red Spot bay when the observations broke off in June, and covered about 75° of longitude on either side of the bay. When next seen in November it appeared very much as in 1903–4, the total length of the shaded area being about 37°, decreasing to about 35° at the end of the apparition. The mean period of the preceding end was $9^h\ 55^m\ 21^s{\cdot}65$, and that of the following end (after conjunction with the Red Spot) $9^h\ 55^m\ 20^s{\cdot}25$, giving a mean period of $9^h\ 55^m\ 20^s{\cdot}95$. In the best observing conditions the complex structure of the dark area was very apparent, consisting of numerous smoky wisps springing from dark knots on the S. edge of S. Equatorial Belt. The brilliant white spots preceding and following the shaded area in the S. Tropical Zone are evidently related to it, and not due to contrast.

(*EFs*) *Other Spots in S. Tropical Zone and S. Edge of S. Equatorial Belt.*—There appear to be several well-defined dark "wave-crests" in the S. edge of S. Equatorial Belt separated by white bays. The best marked of these in 1904–5 almost all occurred in the 120° of longitude following the Red Spot bay. The influence of the "headlong rush" of the great dark area on these markings is very striking, and is dealt with in detail in the note in Part IV. The general tint of the S. Tropical Zone was a bright milky white, brightest just following the Red Spot

bay and on each side of the dark area. Wisps crossing the S. Tropical Zone were very rare except in the region of the dark area.

(*F*) *S. Equatorial Belt.*—Much the most prominent belt on *Jupiter* in 1904–5; broad and very dark, of a rich warm brown tint, which showed up very purple in twilight. The *S.* edge has been dealt with above. It is usually very sharp and clean-cut. The centre of the belt is irregularly rifted, the rift having a decided yellowish tinge in June which was not noticed later. The *N.* edge was more distinct and disturbed than in 1903–4, but it is by no means at a maximum of activity. Owing to the uncertainty of identification, I have not worked out the periods of the spots in this latitude; but it appears to differ little from that obtained in previous years.

(*GK*) *Equatorial Zone.*—Very white with little or no trace of yellow, the S. edge being, as a rule, considerably brighter and more disturbed than the N. edge, though the latter was brightest in 1903–4. The S. edge was active and contained numerous bright spots, while the N. edge was quiescent and remarkably uniform. The activity of the N. edge appears to depend entirely on the breadth and distinctness of the N. Equatorial Belt.

(*H*) *Equatorial Band.*—Very faint, discontinuous, and difficult to see, but certainly more frequently visible than in 1903–4. The wisps crossing the Equatorial Zone were also darker and more frequent this year, though still very difficult to see, except under the best conditions, and rarely traceable N. of the Equatorial band. I can see no signs of the symmetrical arrangement of these wisps described by some observers.

(*L*) *N. Equatorial Belt.*—Very faint and difficult to see well. It seems very narrow, with diffuse edges, and no darker condensations of any sort, being apparently at an absolute minimum of activity. So far as one can judge of colour in so faint an object, it seemed generally a faint colourless grey, with sometimes a slight blue tinge, but always much colder in tone than the S. Equatorial Belt.

(*M*) *N. Tropical Zone.*—Generally fairly bright, but uniform, with very few brighter spots. The activity of this zone also appears to vary with that of the N. Equatorial Belt.

(*MM*) *N. Tropical Belt.*—Very faint and nebulous, with occasionally a very slight bluish tinge. It is very narrow with indefinite edges.

(*NN*) *N. Temperate Zone.*—This is one of the most variable zones on the planet. It is sometimes very bright, and was once in 1904–5 rated as nearly as brilliant as the S. edge of Equatorial Zone. At other times it is very faint and inconspicuous, and generally rather uniform in tone. When brightest it has a milky-white tinge.

(*N*) *N. Temperate Belt.*—Faint and inconspicuous in June, distinct and considerably darker late in the apparition, when a decided sepia tinge was noticed in it. It formed the S. edge of

a very faint yellowish brown shade, which extended from it to the N. Pole.

(*P*) *N.N. Zone.*—Very dull and nearly always slightly shaded. There are very slightly brighter spots here and there in it, but nothing definite.

(*Q*) *N. Polar Region.*—Generally a very decided yellowish brown with once almost a pinkish tinge. It is very slightly striated, and is darkest along its southern edge.

Relative Brightness of Zones.—This was roughly gauged in the same way as in 1903–4 with the following results :—

(G)	S. Edge of Equatorial Zone	1·26
(E)	S. Tropical Zone	2·63
(K)	N. Edge of Equatorial Zone... ...	3·10
(M)	N. Tropical Zone	3·70
(C)	S. Temperate Zone	4·68
(NN)	N. Temperate Zone	5·06
(P)	N. N. Zone	6·87
(A)	S. S. Zone	7·93

Comparing these results with those obtained in 1903–4, the principal changes are the great falling-off in brightness of (K), the N. edge of the Equatorial Zone, and the increase of brightness in (G) S. edge of Equatorial Zone, and (C) S. Temperate Zone.

Rotation-periods in Different Zones.—Owing to the scantiness of the earlier observations, and the large gap (from June to November) which occurred between the earlier and later observations, the identification of many of the markings has been very difficult. I have therefore only worked out the periods for those zones in which the identification can be relied upon. The observations for the other zones have all been booked on the zone diagrams, and are available if required for comparison with the observations obtained by others.

The zones for which rotation-periods have been calculated are as follows :—

(C) S. Temperate Zone ; (D) S. Tropical Belt ; Red Spot ; Great S. Tropical Dark Area ; (EFs) Other Spots in S. Tropical Zone ; and S. Edge of S. Equatorial Belt.

Even in these zones I may have made mistakes in the identification of some of the spots, except in the case of the Red Spot, and the S. Tropical Dark Area, which are unmistakable. The shortness of the period of observation of the E and Fs spots may have led to error in identification, but I think the deduced period may be taken as fairly reliable.

The mean rotation-periods in different zones are given in Table I.

Measures.—No measures could be taken until very late in the

season owing to the absence of a driving-clock. After the new clock arrived I made five sets of measures with the filar micrometer in February and March. The measures were made in twilight, the planet being then very low and the definition, as a rule, unsatisfactory.

I have also measured the latitudes of the principal belts on seven of the best negatives, taken also in February and March. I used an improvised measuring machine, and the negatives are far from perfect, though they show a good deal of detail. The results are fairly accordant; and this method, if carried out with proper apparatus, would, I think, give very valuable results in the future.

In reducing the latitudes no allowance has been made for polar compression.

The means of both photographic and visual measures are given in Table II. The results, compared with 1903–4, seem to show an extension of the S. Equatorial Belt southwards, the motion being shared by the S. Tropical Belt. The N. Temperate Belt appears to have returned to the same latitude as in the early part of 1903.

I also measured the ratio between the equatorial and polar diameters on the photographs. The equatorial diameter is obviously affected by any trail of the image, however slight, during the exposure, which was in some cases as long as thirty or forty seconds. The polar axis was running rather jerkily, so that few of the images are good in this respect.

The mean value from my photographs was 1·000 : 1·084, as against Barnard's value of 1·000 : 1·069; but much better results will be obtained when the clock settles down.

Part III.—Satellite Observations.

These were carried on on the same lines as in previous years (*Monthly Notices*, vol. lxv. p. 696).

The result of the comparisons this year gives the relative brightness of the satellites as follows:

III = 1·02   II = 2·61
I = 2·16   IV = 3·96

These results seem to indicate a slight increase in the light of II. As far as I could judge, IV was, as a general rule, brighter and less bluish than in 1903–4, though still generally the faintest of the four.

The observations as regards colour, albedo, and variability are in complete agreement with those of 1903–4.

The distortion of the shadows near quadrature was well seen on several occasions.

Part IV.—General Remarks.

Cyclical variation in Period.—The observations this year have been too scanty to give good results, but when combined, in a few cases, with the published results of other observers they tend to confirm the conclusions I have already arrived at. The same holds good of the other two special points I referred to in my observations for 1903–4, viz. the *possible extension of the atmosphere of Jupiter* and the *visibility of the Red Spot bay.*

The value of a Driving-clock for delicate work.—The majority of the observations this year were made, as I have already mentioned, without a driving-clock. Hitherto I have regarded this adjunct as a luxury for visual work, but I am now convinced that it is an absolute necessity for the more delicate detail if the best work is to be done. The results this year are, I consider, less accurate than in previous years, and the fatigue to the eye is greatly increased by the strain of following a moving object. Even with the best slow motions there is a perceptible movement of the image when the screw is handled, and I have found it almost impossible to centre the fainter spots on the disc. The quantity as well as the quality of the observations has suffered owing to the number of fainter spots which have been missed. The average hourly number of transits taken this year was 15·8, as against 20 in 1903–4.

The Great S. Tropical Dark Area.—When the observations terminated abruptly in June this area was practically in conjunction with the Red Spot bay, the preceding end having passed the bay just before the observations began, and lying close to the zero meridian of system ii. The following end was still some distance following the bay, which shone up as a large white oval projected on the dark material. The area at the period covered a length of 70°–75° of longitude. I was prevented from watching the passage of the area further.

When next seen (in November) the dark area presented much the same appearance as in 1903–4, its total length being about 37°.

My observations of the preceding end, combined with published observations of Scriven Bolton and Flammarion, show a practically uniform period throughout the apparition, with a slight retardation to about the middle of October, followed by a slight acceleration.

Similarly the observations of the following end late in the apparition, combined with earlier observations of Flammarion, give a very uniform period of $9^h\ 55^m\ 20^s{\cdot}25$. Plotting this and prolonging it backwards, we get August 10 as the probable date of conjunction of the *following* end of the dark area with the *preceding* shoulder of the bay. Taking the observed positions of the following end of the area in June, and assuming the same period, we find that the following end should have reached the *following* shoulder also early in August, and would therefore

appear to have crossed the whole Red Spot bay (about 35° of longitude) almost simultaneously.

The same phenomena seem to have occurred at the last conjunction in 1902 July. As the preceding end of the area reached the following shoulder a dark wisp formed across the S. Tropical Zone at the preceding shoulder and moved down the zone at the normal speed of the dark area. As soon as the following end reached the following shoulder the dark area became complete on the other side of the bay, and moved off at its normal speed down the zone.

It seems impossible that there can be an instantaneous transference of material in this case from one side to the other of the bay, and some other explanation must be sought. The dark area seems to have passed neither *over* nor *under* the bay, but *round* it, by way of the S. Tropical Belt, completely skirting the oval of the bay without encroaching on it in any way. There seems to have been a progressive movement of material throughout the portion of the S. Tropical Belt south of the bay, the movement of the dark area into the belt following the bay causing the extrusion of an equal amount of dark material from the belt preceding the bay. The quantity of matter, so to speak, contained in the belt remained constant, while it acted almost like an incompressible fluid bounded rigidly by the oval of the Red Spot bay.

(This supposed action may be illustrated by taking a slightly curved tube, open at both ends, to represent the S. Tropical Belt at the Red Spot bay. The dark material may be represented by steel balls of such a size as to pass down the tube. If the tube be filled with steel balls and another ball be pushed into one open end, all the balls move, and one is pushed out of the other open end.)

Another peculiarity I have noticed with the dark area is its effect on the rotation-period of the dark "wave crests" in the S. Edge of S. Equatorial Belt and the intervening white spots. Before the formation of the dark area these markings had a period practically identical with that of the Red Spot; but since its formation (1901 May) their period has been very variable, being considerably retarded as the dark area approaches them, and accelerated directly after its passage, gradually returning to the normal. Their behaviour reminds me very much of the buoys in the Suez Canal during the passage of a large vessel. As the ship approaches the buoys are drawn in towards it, and after it has passed follow it as far as their mooring permits. If the moorings possessed considerable elasticity the analogy would be still more complete.

From a careful study of all the phenomena connected with the dark area, I am convinced that it is a well-defined mass of material moving with a high velocity through a slower current, but diverted and repelled in some mysterious way as it nears the Red Spot bay.

The true explanation of these phenomena would do much to increase our knowledge of the atmospheric conditions of *Jupiter*.

Visual Estimates versus *Micrometer Measures*.—There has been a good deal of controversy as to the relative values of these two methods of fixing the longitudes of the markings on *Jupiter*. Personally I am inclined to think that with small sharply defined markings there is little to choose between the two methods if employed by experienced observers. If the markings are very faint or very diffuse, I consider that eye estimates are more likely to give accurate results. Personally, with a micrometer, after taking every precaution as regards focus and parallax, I lose a delicate spot completely as soon as I try to place the wire on it, and I find the same difficulty with the fainter belts when taking measures for latitude.

One great cause of inaccuracy in visual work is, in my opinion, the use of an ephemeris calculated out beforehand for each spot. Each observation should be made perfectly independently without the slightest knowledge of the theoretical time of transit.

My own practice is to note the time of transit of *every* spot which can be seen with sufficient distinctness during the time of observation. The longitudes are never worked out till the transits are booked in the "transit ledger" (generally next day). By this means any possibility of bias is avoided. It is most important, however, as Stanley Williams has pointed out (*Zenographical Fragments*, vol. i. p. 4), that in visual observations the same eye should always be used, and that the line joining the eyes should be kept parallel to the direction of the belts. This, with a Newtonian with revolving head, can generally be easily arranged.

I hope that Professor Hough's strictures on eye estimates will not deter observers from pursuing this extremely valuable work.

TABLE I.

Average Rotation-periods in Different Zones.

Zone.	Approx. Latitude.	No of Spots.	Average No. of Obs.	Average Elapsed Rotations.	Rotation-period.
	°				h m s
White Spots. S. Temperate Zone (C)	−35	11	9·7	453	9 56 20·23
Dark Spots. S. Tropical Belt (D)	−28	2	9·5	583	9 55 27·78*
Dark Spots. S. Tropical Belt (D)	−28	7	17·9	472	9 55 20·63†
Red Spot	−15	3	19·0	672	9 55 40·00
Great S. Tropical Dark Area...	−21	4	26·5	612	9 55 20·95
Other spots in S. Tropical Zone (E) and S. Edge of S. Equatorial Belt (Fs) ...	−15 to −21	9	9·2	209	9 55 53·97

* Abnormal. † Normal.

TABLE II.

Latitudes of Belts from Measures.

	Distance from Centre of Disc at Mean Distance 5·20				
	(D) Centre of S. Trop. Belt.	(Fs) S. Edge of S. Eq. Belt.	(Fn) N. Edge of S. Eq. Belt.	(L) Centre of N. Eq. Belt.	(N.) Centre of N. Temp. Belt.
Average of 5 Visual Measures ...	− 9″·52	− 6″·41	−3″·00	+ 2″·70	+ 8″·72
Average of 7 Photographic Measures	− 9·70	− 7·12	−2·70	+ 2·68	+ 8·85
Mean ...	− 9·61	− 6·77	−2·85	+ 2·69	+ 8·78
Apparent latitude	−32°·33	−22°·13	−9°·13	+ 8°·60	+29°·25
Correction to centre at mean date (1905 March 4)	+ 2·74	+ 2·74	+2·74	+ 2·74	+ 2·74
True latitude (ϕ) ..	−29·59	−19·39	−6·49	+11·34	+31·99

The Annular Nebula in Lyra (M 57). By E. E. Barnard.

In *Monthly Notices* of the Royal Astronomical Society for 1900 January I have given a paper on the Annular Nebula of *Lyra* (*M* 57), in which it was shown that measures of the central star of the nebula with reference to a 12^m star (a) following, made by Professor Burnham in 1891, consistently differed from measures made by the writer in 1898 and 1899 by 1° in angle and 1″ in distance. The distance had apparently diminished, and it was there suggested that this difference might possibly be due to motion in the nebula.

Professor Asaph Hall had measured a number of small stars about the nebula in 1877 with reference to a. These stars were remeasured by me in 1899, but they did not indicate any motion in a; they seemed to be stationary, with the possible exception of the star f. Professor Hall did not see the central star, and hence there are no measures prior to those of Professor Burnham.

In 1900 February Professor Scheiner and I measured at Potsdam a negative made by Dr. Scheiner in 1894 October 29 (see *Monthly Notices*, January 1900, p. 257), which gave results that did not verify the suspected change in the position of the nucleus.

In 1900 September Professor F. P. Leavenworth, of the University of Minnesota, measured these stars and the nucleus on several negatives taken by him in 1897–1900 (see *Monthly Notices*, vol. lxi. p. 25).

In 1902 Mr. Burt L. Newkirk, of Minneapolis, from all the measures, determined the proper motion and the parallax of the